Anticipation Rapid Fielding

Technology Tools for Rapid Capability Fielding: *Final Outbrief*

Superior Capabilities

Cleared for Open Publication by DoD Office of Security Review
Case 10-S-0787, Jan 25, 2010

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
25 JAN 2010		**00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Technology Tools for Rapid Capability Fielding: Final Outbrief	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Department of Defense,Washington,DC**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**29**	

Agenda

- Executive Summary
- Background
  - Terms, objectives, study approach
- Findings
  - Points of leverage in rapid capability life cycle
  - Specific technology areas - engineering, M&S, manufacturing
  - Concept to Capability Engineering
- Conclusion

Executive Summary

Findings

- Significant opportunities exist to develop and deploy technologies to strengthen the Department's ability to conduct rapid capability fielding
  - However, non-technical challenges (e.g. cultural, budgetary, contracting, etc) must be simultaneously addressed
- Greatest leverage in the "front end" of the life cycle
  - Concept Engineering: Rapidly elucidating the need, exploring solutions, developing CONOPs, and deriving requirements for materiel solutions
    - Virtual environments and rapid physical prototyping are linchpin technologies
- Opportunities exist to increase design, test, and production efficiencies
  - Examples include physics-based M&S to reduce testing and model-based engineering and manufacturing approaches

Recommendations

- A concept engineering center should be implemented immediately that leverages the substantial existing capabilities across the Department
- A strategic R&D roadmap should be developed and implemented to mature and transition emerging tools and promising innovative ideas
- A set of potential pilots is recommended to demonstrate the application of today's toolset to relevant rapid capability challenges

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Terms of Reference

- **Objective:** Provide specific recommendations to DDR&E regarding **technological opportunities** to significantly **decrease the development time** and **increase the operational effectiveness** of rapidly fielded capabilities.
- **Study Questions:** What are the current technical tools used in both the defense and commercial industries to rapidly design, fabricate, test and validate new systems?
  - Pay particular attention to **modeling and simulation** tools to support rapid design, fabrication, and testing; **system engineering** tools to rapidly design and re-design complex systems; and **manufacturing** processes and tools to speed development.
  - Are there tools that would allow for end to end rapid development, to include such functions as CONOPS development, interoperability, and testing?
- For each of these tools, assess their current capabilities and limitations for DoD rapid fielding needs.
- What are the **emerging technology opportunities**? Identify the technical leaders in these areas and propose approaches to validate the impact of these tools.
- How might these technology opportunities best be developed? **Program scope, scale, and schedule**? Suggestions as to how this might best be done, and by whom are invited.
- Is there any way to **tailor current tools**, techniques, models, methodologies, best practices, etc, to achieve better rapid fielding capability immediately?

Defining Terms

- Rapid Capability Fielding: *Streamlined projects seeking to field capability in less than 24 months.*
  - *This could be in response to a stated need of a combatant commander or in anticipation of a potential need*

- Technology Tools: *Software, algorithms, models, simulations, manufacturing hardware/software, and associated processes that support the full life cycle of rapid development*
  - *In general, organizational, contracting, budgeting, and other non-technical aspects of rapid fielding are off the table*
  - *To the extent human resources, organizational issues and processes are integral to technical recommendations, they should be addressed*

Panel Membership

- *Jim Carlini (Study Lead):* Consultant, former Vice President for Advanced Development, Northrop Grumman Electronic Systems
- *Mark Burgess:* Chief Engineer, Boeing Research and Technology
- *Dennis Roberson:* Vice Provost, Illinois Institute of Technology and former CTO, Motorola
- *Yngvar Tronstad:* Executive Vice President and Chief Scientist, Cogility Software
- *Dinesh Verma:* Dean, School of Systems and Enterprises, Stevens Institute of Technology
- *Bran Ferren:* Co-founder, Applied Minds and former President, Walt Disney Imagineering
- *Study Coordination and Support*: ANSER Corporation, Dr. Mike McGrath and team

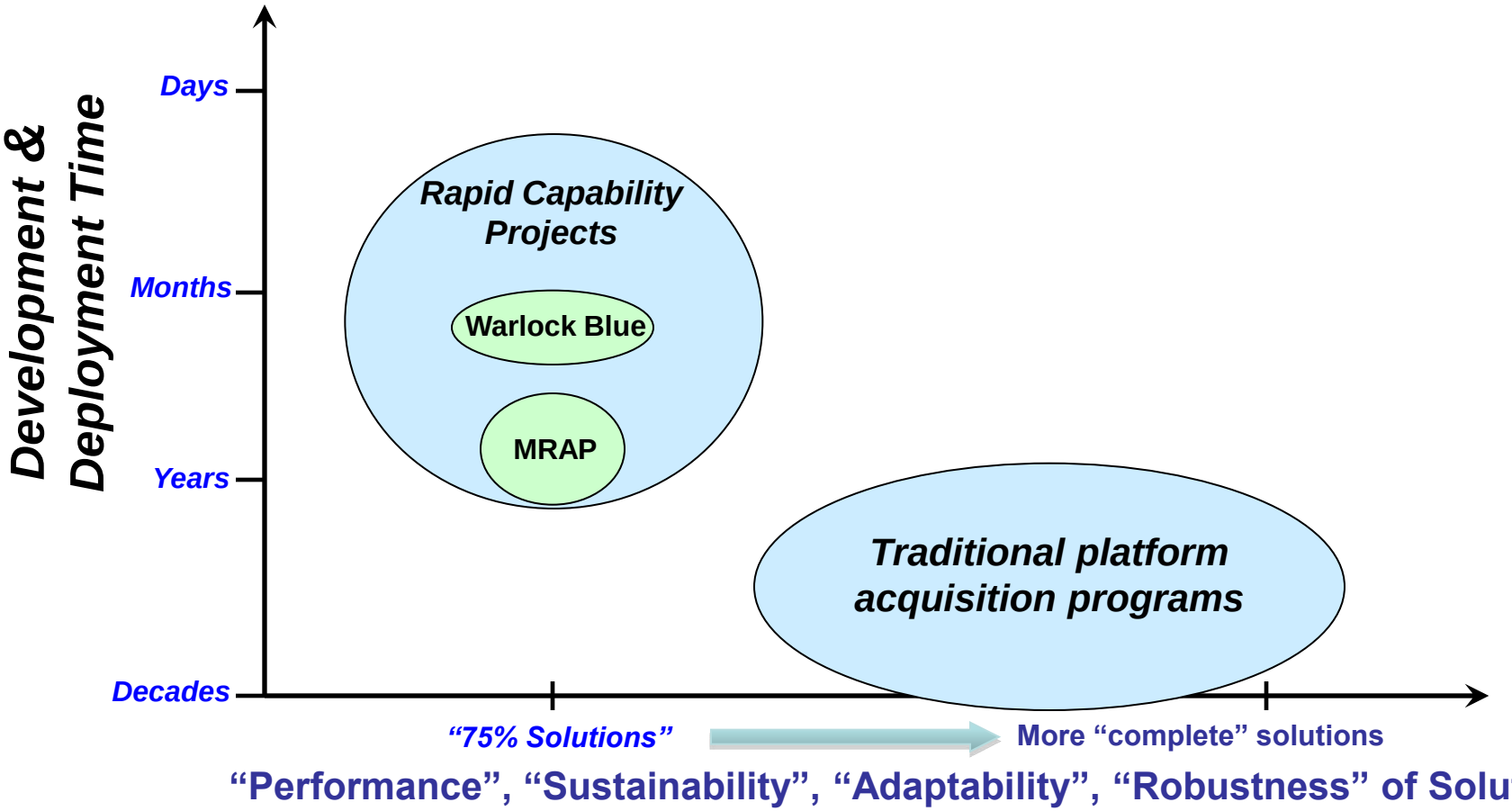
Caveats

- Technology tools are not the primary answer to the challenges of rapid fielding
  - Contracting, organizational, cultural, budgeting, and other problems are paramount and must be tackled
- Nevertheless, technology has a role and if integrated into a composite overall solution can have great impact
- Gaining full insight into all relevant Department efforts and technology areas impossible within timeframe
  - Some recommendations require additional research and coordination across the Department

What are we trying to help enable with "technology tools"?

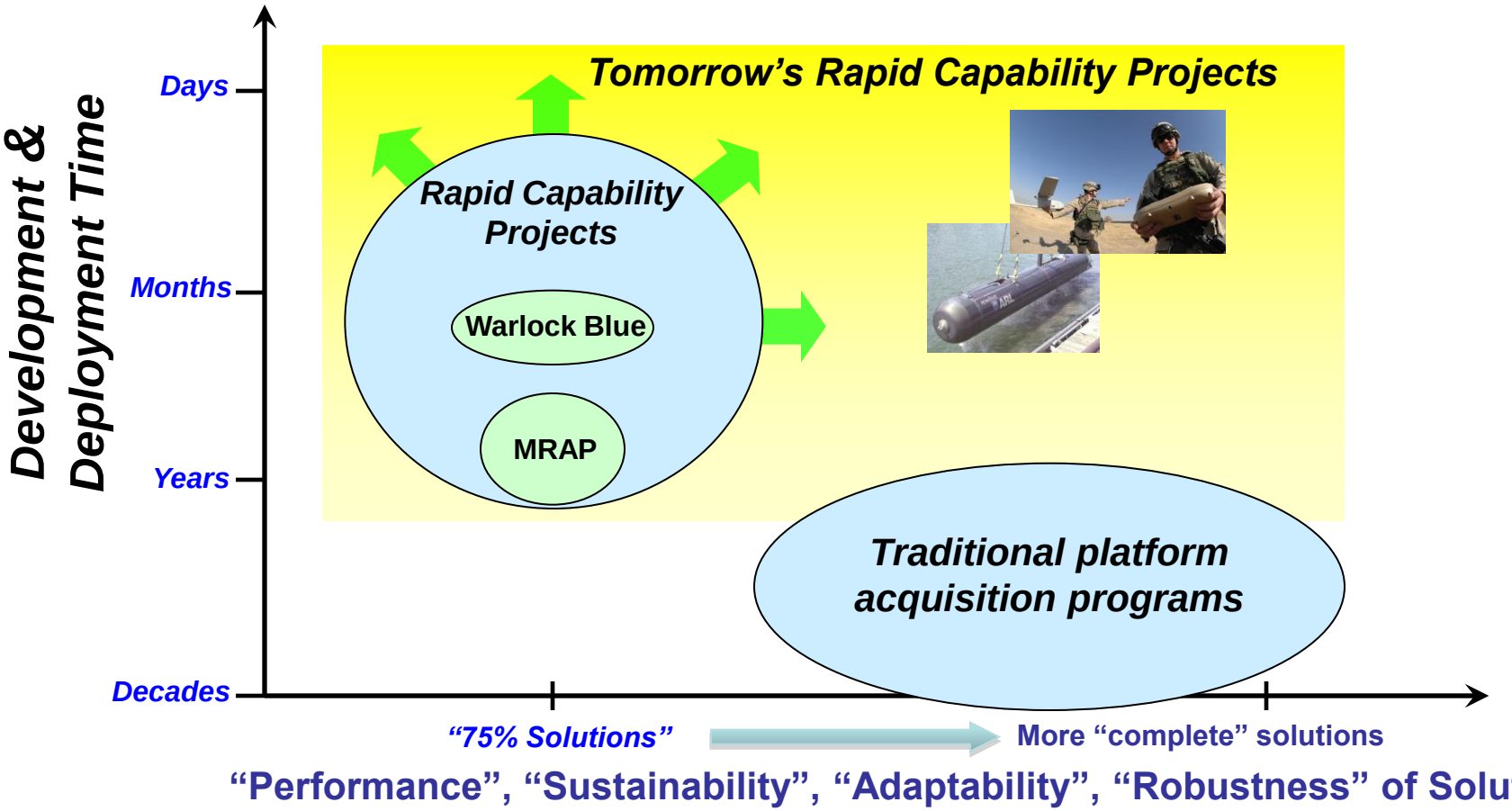
- Shorten time from need to fielding
  - Reduce time for individual steps in the life-cycle
  - Reduce number of iterations of "design-build-test-produce-field"
- Anticipate and prevent emergence of urgent needs
- Ensure the solution adequately addresses the "need" and has the desired operational longevity
- Move rapid capability fielding from heroic to routine
  - May not decrease the time of an individual project, but enable moving toward a "steady diet" of rapid projects
- Ease transition to a POR
  - Prevent starting from scratch again

Enabling Better Rapid Capability Fielding



DDR&E Rapid Capabilities Technology thrust will develop capabilities to enable more rapid, adaptive, robust, and sustainable solutions to the warfighter

Enabling Better Rapid Capability Fielding



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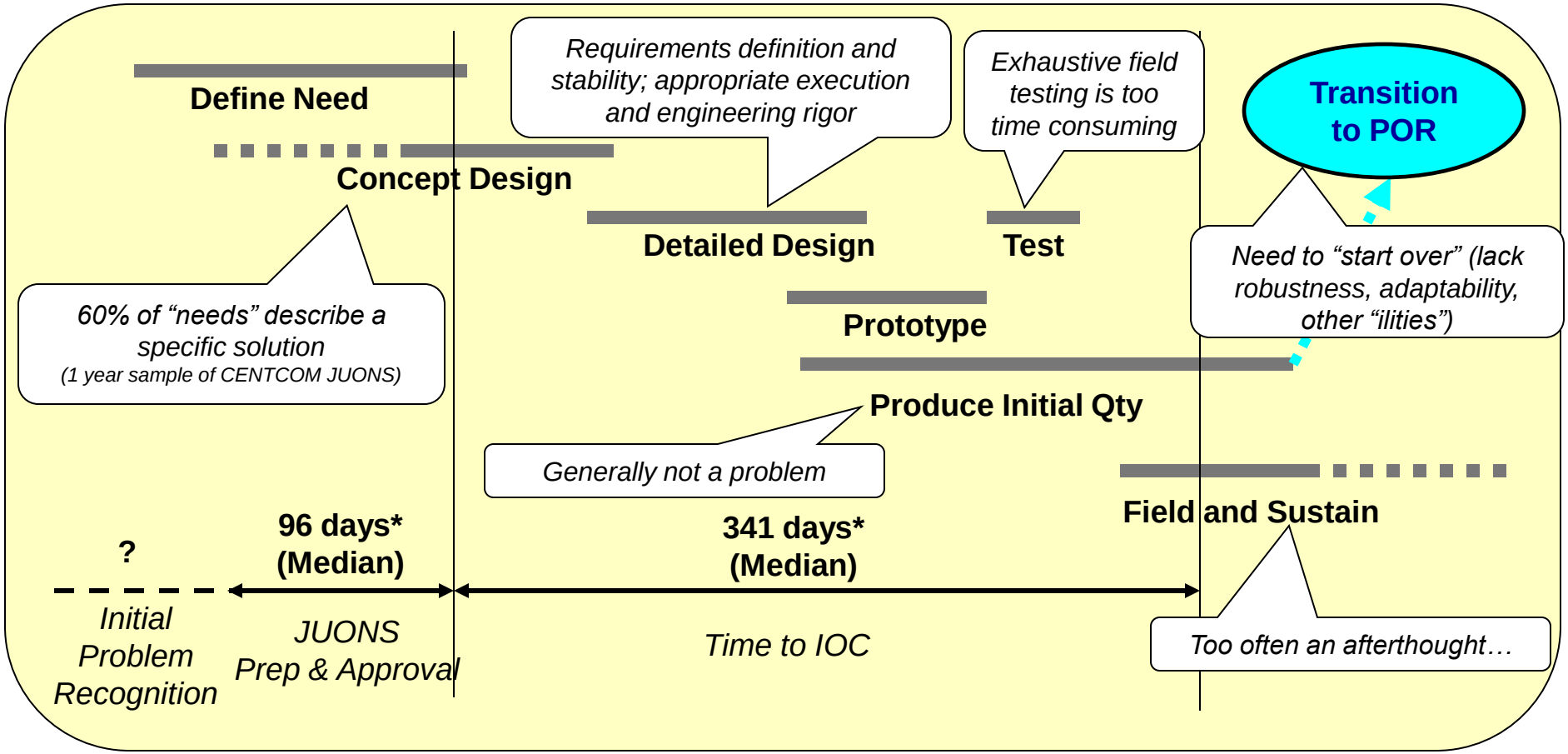
General Observations



Extraordinary work is being done across the Department to fulfill warfighter needs, but opportunities abound to strengthen rapid capability fielding

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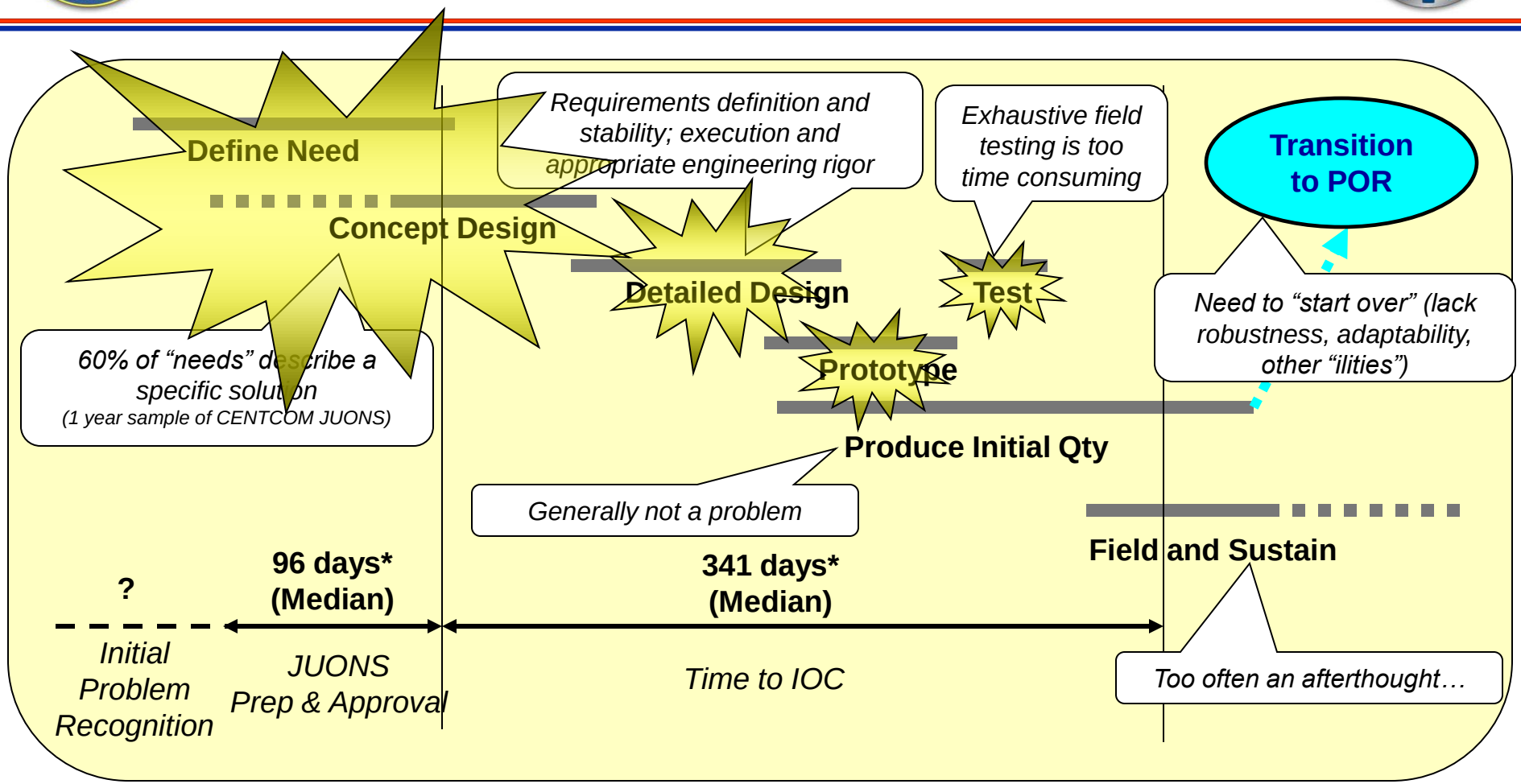
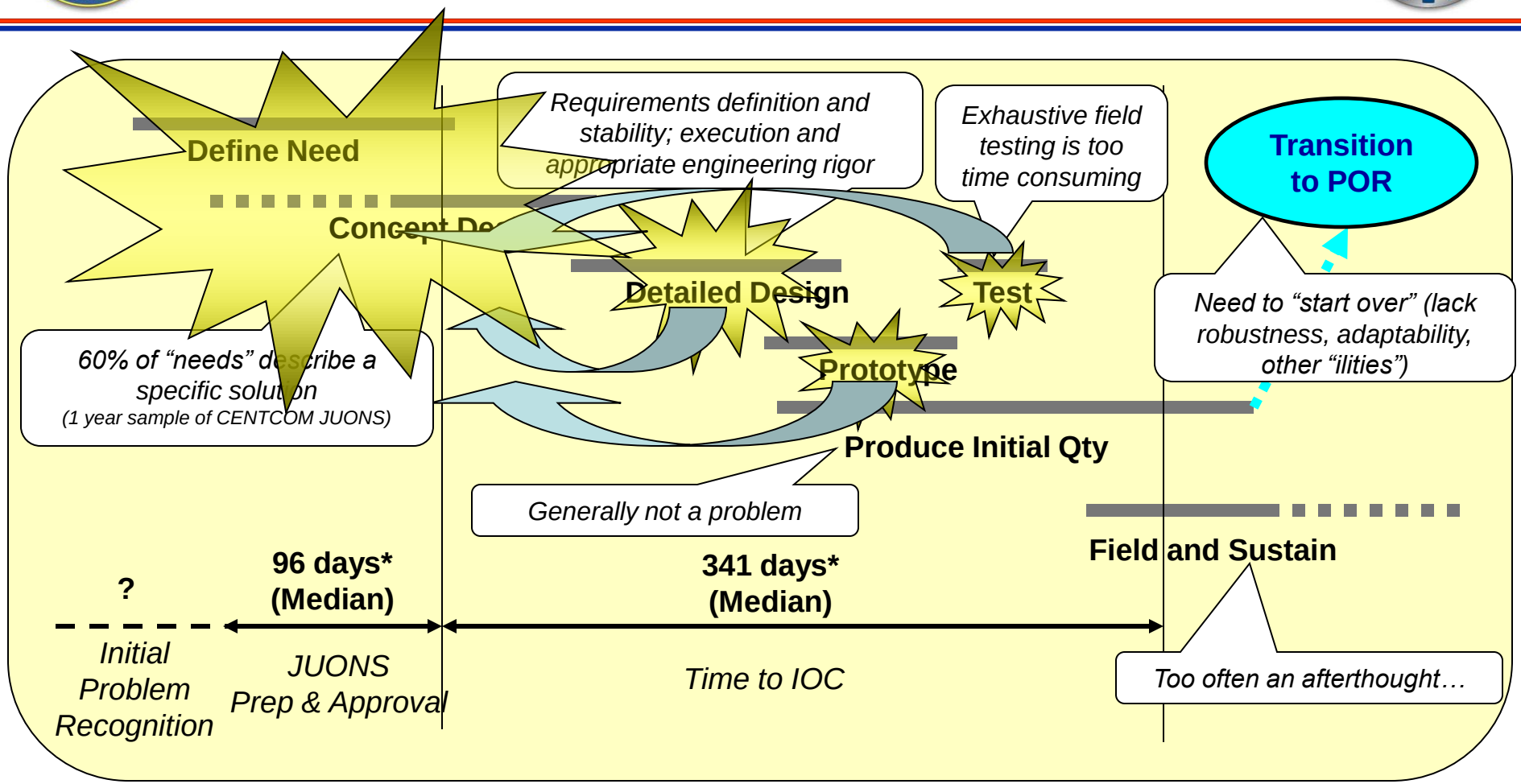
*2009 DSB Report

Where is the Leverage?



Get it right up front: anticipate, properly define the need and technical requirements, assess options/CONOPS, account for sustainment (or obsolescence)…..

Where is the Leverage?



…….and invest in the tools and training to help speed/automate detailed design, test, and fabrication to compress the development life cycle

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*2009 DSB Report

Spectrum of Rapid Capabilities Solutions

Air/Land/Sea Vehicles

Unmanned Systems

Electronics

Info Systems (C2, Decision Support, Social Networking, etc)

CBRNE Defense, Forensics

. . . . . .

Domain-specific challenges abound – a well-populated toolbox with extremely flexible processes and dedicated, top-notch personnel is essential

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Engineering Findings

- Engineering discipline in rapid capability projects is mixed
  - Ranges from virtually none to “5000-lite”
  - No standard method for determining the appropriate level
- Starting from existing engineering processes is not the best approach:
  - One size fits all systems engineering, focused on comprehensiveness, not agility
  - Process-focused vice outcomes-focused (documenting versus creativity)
  - Front end is particularly lacking in tools leveraging advances in visual modeling, virtual environments, and rapid prototyping
- Cross-cutting challenges
  - Inability to rapidly assess “–ilities” (reliability, producibility, testability, etc.)
  - Accreditation times can limit the ability to field rapidly
  - Reverse engineering tools needed (important for integration with legacy systems)
- Trends
  - Commercial use driving progress in Model Based Engineering
  - Tools and tool interoperability getting better, but ways to go
    - Software: Advances have been made in autogeneration of code, however effective and efficient translation from CONOPS (use cases) to executable models requires more work
    - Hardware: Translation of abstract high level system models (architecture models) to CAD/CAM not there yet (except for microelectronics), but needed….
      - Proposed research in design using hierarchical abstraction (i.e. Eremenko, DARPA) can be a catalyst
  - Increasing use of virtual environments and digital threads (design through manufacturing)

Modeling and Simulation Findings

- Community is vast, with a good deal of excellent work occurring in pockets
- Training community leveraging emerging technologies (e.g. gaming, virtual, mixed, augmented reality)
  - Appears to be little exploitation in acquisition communities
- Ability to easily and rapidly develop gaming scenarios is impressive
  - Work still needed in enhancing realism and physics-based effects
- Physics-based simulation applied to engineering design holds the promise of having a substantive impact on rapid capability fielding
  - Reducing design-build-test cycles (e.g. Goodyear, P-3 sensor integration)
  - Development efforts are expensive and lengthy
- Platform EMI and battlefield communications modeling efforts exist, however a rapid battlefield electromagnetic modeling effort should be explored
- Ability to model human/cultural behavior limited
  - Agent-based modeling coupled to Monte Carlo with real world calibration may hold promise
- There is limited visibility into existing DoD-wide M&S capabilities that might be applied to rapid capability fielding efforts
  - Interoperability also an issue

Manufacturing Findings

- Manufacture of modest quantities is not usually a rapid capability challenge, but:
  - Many examples are “heroic” and not a sustainable business model
  - Quick-reaction production capacity when large numbers are needed may be an issue
- DoD Labs have substantial in-house capabilities
  - Distributed across many sites – need to make visible and accessible
  - Need to keep current with emerging tools and technology
- Focus for rapid prototyping should be:
  - Physical mockups to aid in user-centered design and CONOPS development
  - Functional prototypes to aid in validating engineering concepts
- Focus for limited production should be on total manufacturing time, not just time-on-tool -- leverage is above the shop floor and in supply chain
- Emerging tools:

Rapid (Functional) Prototyping

- Additive Manufacturing (3-D printing, laser sintering, etc) for mechanical parts
- Ink-jet printing of circuit boards and solderless circuit card assembly

Limited Production

- Model Based Enterprise – visualizations and physics based process simulations to generate mfg controls and acceptance test programs
- Tool-less processes (e.g. composites sans autoclave)
- Collaborative Mfg Architectures and standards for discovery and integration of mfg services

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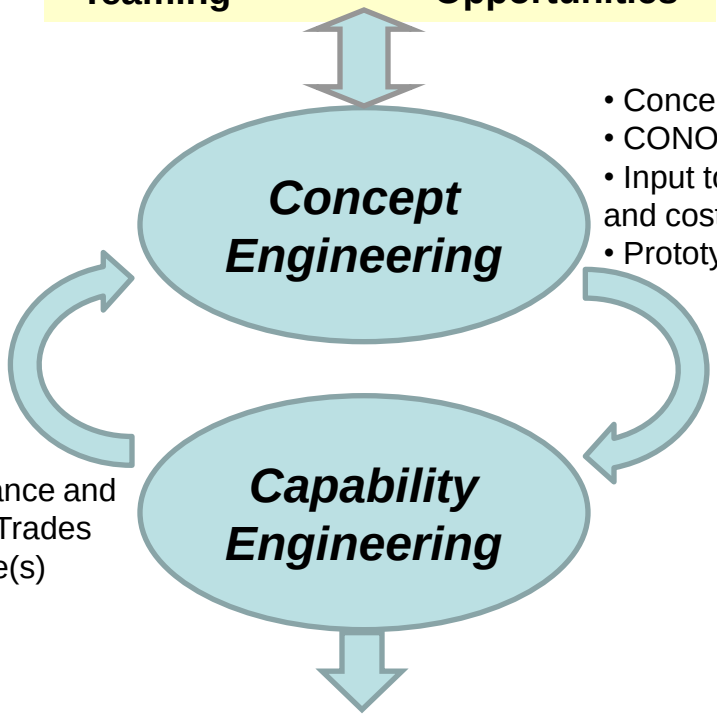
Tool-enabled Rapid Capability Development

Near

Needs (Stated and Unstated)

Red Teaming

Tech Opportunities



- Conceptual Design
- CONOPS/TTPs
- Input to detailed design and cost/benefit trades
- Prototype(s)

- Performance and Materiel Trades
- Prototype(s)

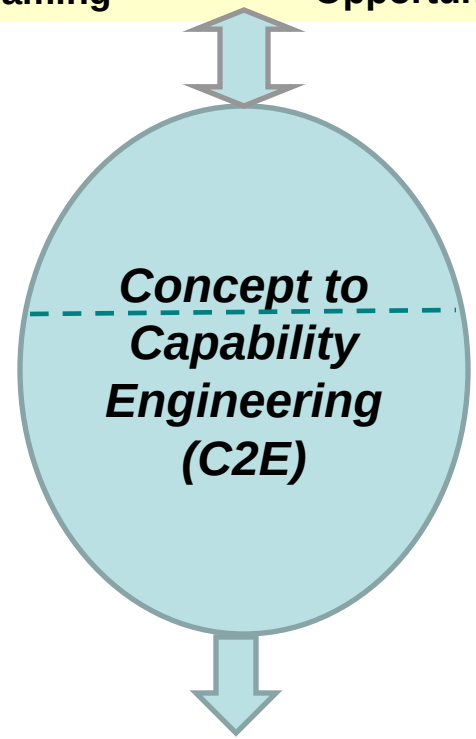
Fielded Capabilities

Far

Needs (Stated and Unstated)

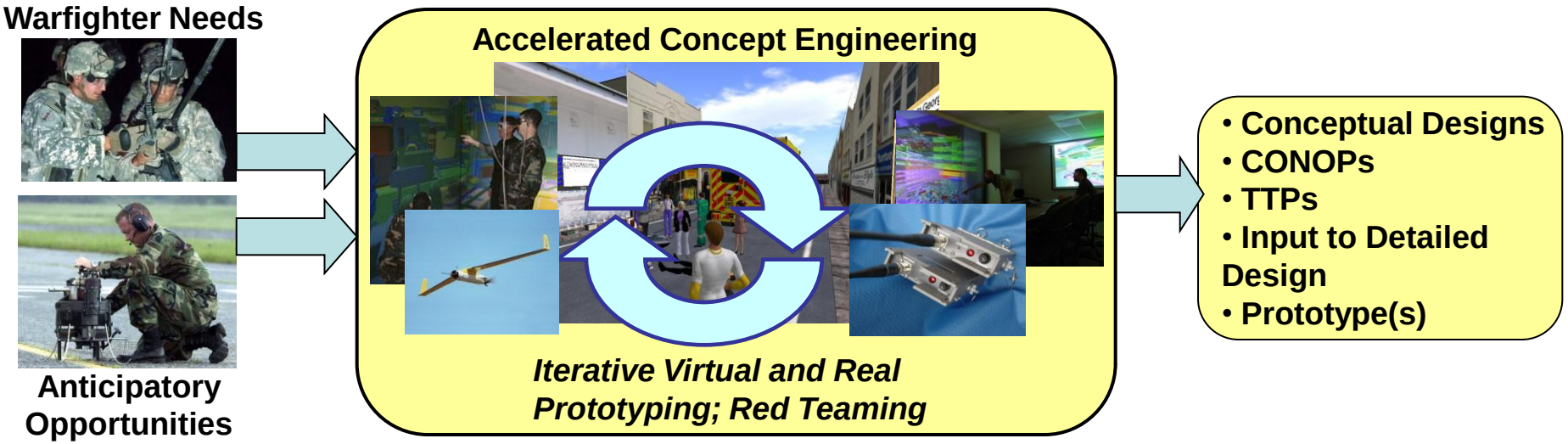
Red Teaming

Tech Opportunities



Fielded Capabilities

Concept Engineering



- Need/mission focused (the right tool(s) to answer the question)
- Warfighter-centric (CONOPS integral, real prototypes where possible, user-centered design and development)
- A persistent environment that favors speed over fidelity
  - Responsive to needs, but also anticipatory
  - Work collaboratively with higher fidelity simulations (e.g. SIMEX), physical exercises, and field experiments

Immerse Users/Developers in a Rapidly-Configured Environment with Real and Virtual Prototypes: *Accelerated Concept Engineering*

Concept Engineering Tools

Virtual Environments

- Persistent, virtual environment
- Gaming, virtual/mixed/augmented reality, 3-D visualization
- Rapidly create relevant environment to explore concepts and CONOPS
- Couple to physical prototyping where user interaction important
- Real-time user feedback
- Bootstrap training
- Remote users

User-centered Design

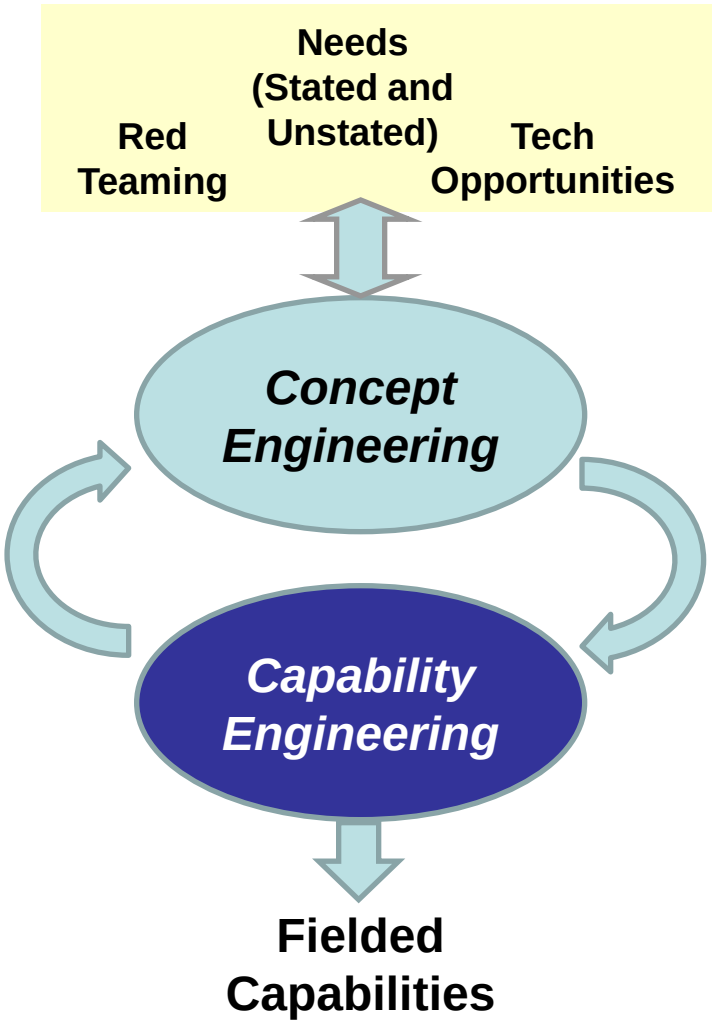
- Create routine user-centered feedback
- Employ selected tools and techniques from "design" community (i.e. IIT, Stanford, Ideo Inc)
- Build upon DARPA TIGR and network of forward-deployed S&T personnel
- Systematically anticipate needs and user-centered design factors
- Iterate with CONOPS

Rapid Prototyping

- Where possible, rapidly develop physical prototypes of candidate concepts
  - Physical mockups and functional prototypes as technology permits
- Inform CONOPS development, user interfaces, logistics and maintenance driven changes
- Leverage vast array of capabilities across DoD
- Over time, seamlessly integrate with virtual environment

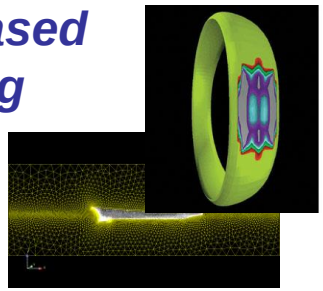
Capability Engineering

- Rapidly move from concept engineering (conceptual design, CONOPS/TTPs, prototypes) through detailed design, production, and test
- As needed, iterate with concept engineering
- Explicitly account for “ilities”
- Where possible, use physics based models
  - Inform the design and minimize re-work
  - Reduce testing time
- Over time, move to model-based engineering and manufacturing
  - Greatly enhance future system modification speed and efficiency
- Automate the seam between concept engineering and capability engineering (“C2E”)
  - Move from documents to models, virtual environments to CAD



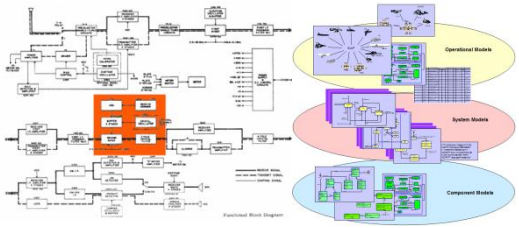
Capability Engineering Tools

Physics-based Modeling



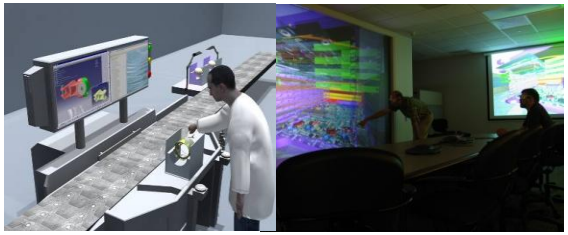
- Minimize rework and speed T&E
- Key enablers: physics understanding, reusable models, interoperability, VV&A
- Domain specific: weapons, platforms, electromagnetics

Model-based Engineering



- Increase automation, efficiency, CM
- Key enablers: pre-architected modular solution patterns, design libraries and design rules, DFx tools, reverse engineering tools, standards for tool interoperability, increasing abstraction and autogeneration capabilities, CAD-to-VE interface
- Domain specific: mechanical, electronics, software domains

Model-based Manufacturing

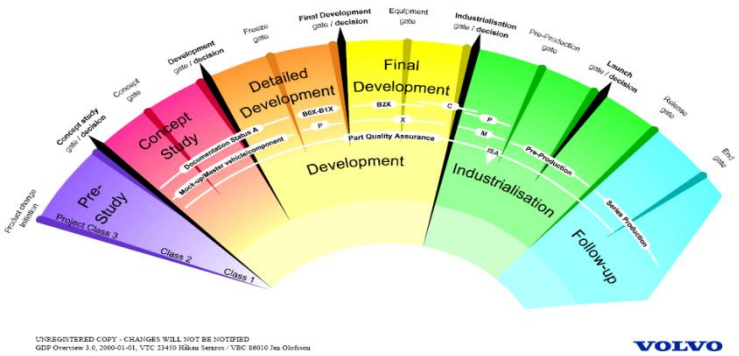


- Increase automation, efficiency
- Key enablers: physics based process models, auto-generation of manufacturing controls, auto-inspection, robotic assembly, advanced visualization
- Domain specific: flexible processing and fabrication technologies, “tool-less” where possible

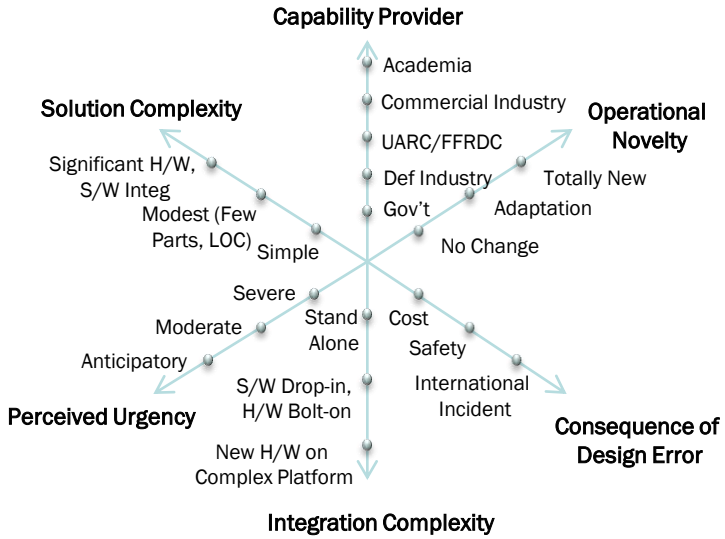
Tailored Systems Engineering and Execution Strategy

- Early, small execution strategy workshop
  - < 10 very seasoned people; < 4 hrs
- Qualitatively assess risk (technical, execution, acceptance)
- Consciously impose desired operational longevity
- Start from zero process and work up (not 5000 and work back)
- Hybrid of a la carte and "packaged strategies"
  - Review gates, personnel requirements
- Depend on judgment, not process
- Capture "packaged strategies" over time with honest assessment of utility/outcome

Commercial Industry Example…



….Unique DoD Rapid Capability Challenges



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